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(IN VITRO) EVALUATION IONIC RELEASE OF TWO TYPES OF DENTAL BASE CASTING ALLOYS (CO/CR), (NI/CR) IN DIFFERENT PH MEDIA, COMPARATIVE STUDY

Najwah Y. Hameed* and Assist. Prof. Mohammed A. Hamid*

Middle Technical University, College of Health and Medical Technologies/Baghdad.

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***Corresponding Author**
Najwah Y. Hameed
Middle Technical University, College of Health and Medical Technologies/Baghdad.

ABSTRACT

Background*:** Corrosion is always accompanied by release of element. Release of metallic ion from the metallic- lattice of dental alloys into the oral cavity occurs. Chloride, sulfides, and oxides, are formed during this process, the release ion from dental alloy is considered to be gradual and to occur in small amounts.[1,2] The release of metallic ions from high noble, noble, and base dental casting alloys under differing PH condition which simulated the oral cavity.[3-5] ***Objective*:** Evaluate the release of ion from two commercial available dental casting base metal alloys cobalt-chromium (Co-Cr), nickel-chromium (Ni-Cr) in three different PH media. ***Material and method: Sixty disks shaped of (5mm) in diameter and (3mm) in thickness of base metal alloy samples participated in this study divided into two main groups according to the type of metal alloy; 30 samples made of (Co/Cr) alloy and 30 samples made of (Ni/Cr) alloy. Estimation the ion released from these alloys which are (Co, Ni, Cr and Mo) after immersion in artificial saliva of different PH levels (2.3, 6.5) & saline solution PH (7.3) for 30 and 60 days durations. The analytical technique used for elemental differentiation was done by the use of inductively coupled plasma atomic emission spectrophotometer (ICP-AES). ***Results:*** T-Test was used for statistical analysis of results. For all ions, PH and period interactions were statistically significant. ion release result were highest in artificial saliva of PH2.3 and didn't release anything in PH (6.5, 7.3). The major amount ions released within first 30 days. **Mo** in (Ni/Cr) alloys level is higher than (Co/Cr) alloys a statistically highly significant difference (P=**0.00**, **P<0.01**). Anon-significant difference (P=**0.175**, **P>0.05**) between **Ni** ion release and **Co** ion release. Non-significant difference (P=**0.354**, **P>0.05**), when compared between mean of total Ions realized from (Co/Cr) alloys level & (Ni/Cr) alloys.

KEYWORDS: dental base casting alloy (Co/Cr) & (Ni/ Cr), Ion release, PH changes.

INTRODUCTION

Alloys that are used for dental prostheses must possess certain properties, such as good physical properties, biocompatibility, good mechanical properties such as high hardness, strength and excellent corrosion resistance.[6] However, their dental applications became restricted because of the increasing cost of gold during the (1980s).[7]

Base metal casting alloy cobalt-chromium and nickel-chromium alloys today are widely used in prosthetic dentistry for the fabrication of fixed and removable partial dentures because of their lower cost. Many dental casting alloys which have good mechanical properties, on the other hand aren't good enough from the aspect of corrosion because of their complex structure[8] Ions released during corrosion may be detectable by the patient. Released metallic components may also cause an undesirable metallic taste. Given these unpleasant circumstances, the patient may request for the restoration to be removed.[5]

The materials employed in the mouth must be completely corrosion-resistant, they must not react with many alkaline and acid foods that are taken into the mouth, and they must not be affected by mouth fluids.[9] However the acidity or alkalinity of the fluids measured in the oral cavity by pH varies from around 4 to 8.5, while the intakes of acid fruit juices or alkaline medicaments can extend this range from pH 2 to 11.[10] Metal ions which are released from dental alloys in the humid oral cavity medium can lead to either toxic or allergic responses. They can be transferred to distant organs, thereby causing different changes.[11] The purpose of this study to evaluate the influence of different pH media ion release of (Co-Cr - Ni- and Mo) from cobalt-chromium (Co/Cr) & nickel-chromium (Ni-Cr).

METHODOLOGY

Preparation of samples

Mold preparation: Sixty disk shaped wax samples of 5 mm in diameter and 3 mm in thickness. Produced by the silicon mold (**Figure 1)**.

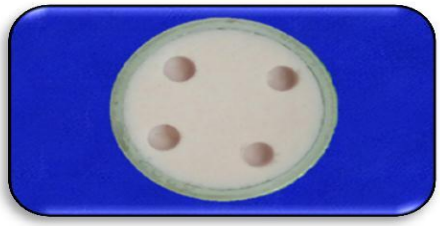

Figure 1: Silicon mold.

Thirty wax samples for Co/Cr and 30 wax samples for Ni/Cr are prepared by pouring molten inlay wax into the silicon mold. Carried out as per the manufacturers' recommendations, a Co/ Cr based alloy for removable partial denture (supper 6, USA), a Ni/Cr based alloy for fixed partial denture (supper 11, USA). Alloys were cast into disks of 5 mm in diameter and 3 mm in thickness (n=30 per alloy) and polished (**Figure 2**).

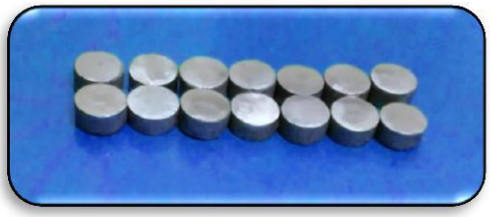

Figure 2: Polished Samples.

Preparation of artificial saliva: We used the following ingredients to prepare the artificial saliva which are: 7.69 g of K2HPO4, 2.46 g of KH2PO4, 5.3 g of NaCl, 9.3 g of KCl Were added to 1,000 mL of distilled water. The resultant vehicle which is artificial saliva was divided and stored into two glass container each container 500mLprocedures done according to ISO 10271:2001standard.[12]

- The three test solutions were used for immersion are:-

Group (A): artificial saliva with PH 2.3.

Group (B): artificial saliva with PH 6.5.

Group (C): Saline solution at PH 7.3, **(Table 1)**.

Table 1: Test solution.

PH	Code	Composition(mL)
2.3	A	12 mL lactic acid to 500 mL artificial saliva
6.5	B	(0.9% NaCl +0.126 g NaOH) to 500 mL artificial saliva
7.3	C	Saline solution (0.9% NaCl)

Immersion test: 15 mL of each test solution was poured into polypropylene test tube. Metal samples washed in distilled water and alcohol, each sample was put in a test tube which is labeled according to PH level. All test tubes place in tubes rack and incubated at 37˚c.

Metallic ions released tester

- **First measurement**: After 30 days of immersion of the samples in artificial saliva. The solution in each test tube group (A, B, and C) was examined to assess ion released (Co, Cr, and Mo) of group one (Co/Cr) alloy.
- Second measurement: After 60 days of immersion of the samples in artificial saliva. The solution in each test tube group (A, B, and C) was examined to assess ions released (Co, Cr, and Mo) of group one (Co/Cr) alloy. The same procedure (first and second measurement) was applied on group two (Ni/Cr) to assess the ion released (Ni, Cr, and Mo). Metallic ions released were measured by inductively coupled plasma atomic emission spectrophotometer (ICP-AES) which provide an analytical technique used for elemental determination **(ISO/IEC 17025:2005)**.Each reading was used to determine the mean concentration of the different elements in part per million (ppm) released from alloys.

RESULTS

Sixty metal based alloys 30 samples were (Co/Cr) and 30 samples were (Ni/Cr), estimation the ions released (Co, Ni, Cr, & Mo) after immersions in artificial saliva with different levels of PH (2.3, 6.5 & 7.3) Only 20 samples (10 Co/Cr & 10 Ni/Cr) that immersed in artificial saliva (A.S) at PH = 2.3 released the ions. Another PH (6.5 & 7.3) didn't release anything.

This study show ions released from both type of alloys (Co/Cr) & (Ni/Cr) after 1st 30 days, (table 2) & (figure 3), Ni level (0.213±0.032) less than Co level (0.263±0.052), with significant difference (P=0.018, P<0.05). Also, Mo level of (Ni/Cr) alloys (0.203±0.022) more than (Co/Cr) alloys (0.073±0.036), a statistically highly significant difference (P=0.00, P<0.01) was shown. Eventually, (Co/Cr) alloys Cr level (0.058±0.033) while from (Ni/Cr) was Zero statistically highly significant difference (P=0.00, P<0.01) was shown.

Table 2: Mean comparison of Ion releasing (Co/Cr) & (Ni/Cr) after immersion 1st 30 days in artificial saliva (A.S) at PH = 2.3.

Ion releasing after immersion 1st 30 days in A.S. PH = 2.3		N	Mean ppm	Std. Deviation	t-test (P-value)
CO & Ni	Co (Co/Cr)	10	0.263	0.052	P=0.018
	Ni (Ni/Cr)	10	0.213	0.032	Sign. (P<0.05)
Cr	Co/Cr	10	0.058	0.033	P=0.00 Highly
	Ni/Cr	10	0	0	sign. (P<0.01)
MO	Co/Cr	10	0.073	0.036	P=0.00 Highly
	Ni/Cr	10	0.203	0.022	sign. (P<0.01)

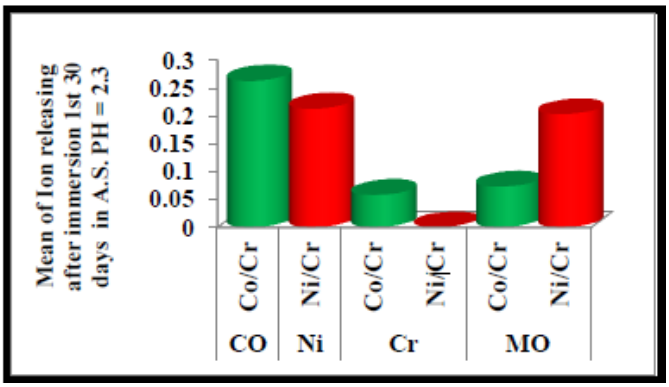

Figure 3: Mean comparison of Ion releasing (Co/Cr) & (Ni/Cr) after immersion first 30 days in artificial saliva (A.S) at PH = 2.3.

(Table 3) & (figure 4), noted that Ions released mean comparison between alloys (Co/Cr) & (Ni/Cr) after 2nd 30 days, Ni mean level (0.177±0.029) larger than Co (0.053±0.022), highly significant difference (P=0.00, P<0.01). Moreover, non-significant difference (P=0.921, P>0.05), reduced mean of Mo level in both (Co/Cr) alloys (0.091±0.017) & (Ni/Cr) alloys (0.092±0.026). Finally, (Co/Cr) alloys Cr mean level (0.058±0.027), but (Ni/Cr) level was Zero statistically highly significant difference (P=0.00, P<0.01) was shown.

Table 3: Mean comparison of Ion releasing (Co/Cr) & (Ni/Cr) after immersion 2nd 30 days in artificial saliva (A.S) at PH = 2.3.

Ion releasing after immersion 2nd 30 days in A.S. PH = 2.3		N	Mean ppm	Std. Deviation	t-test (P-value)
CO & Ni	Co (Co/Cr)	10	0.053	0.022	P=0.00 Highly
	Ni (Ni/Cr)	10	0.177	0.029	sign. (P<0.01)
Cr	Co/Cr	10	0.058	0.027	P=0.00 Highly
	Ni/Cr	10	0	0	sign. (P<0.01)
MO	Co/Cr	10	0.091	0.017	P=0.921 Non
	Ni/Cr	10	0.092	0.026	sign. (P>0.05)

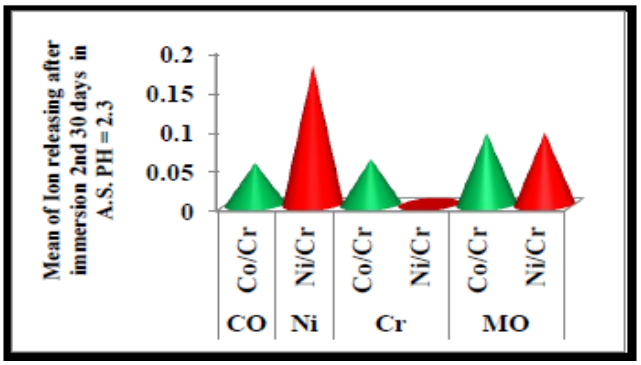

Figure 4: Mean comparison of Ion releasing (Co/Cr) & (Ni/Cr) after immersion 2nd 30 days in artificial saliva (A.S) at PH = 2.3.

Ions released for both type of alloys (Co/Cr) & (Ni/Cr) after 60 days, (table 4)& (figure 5), reported that the mean of Mo in (Ni/Cr) alloys level (0.148 ±0.062) higher than (Co/Cr) alloys (0.082±0.029), a statistically highly significant difference (P=0.00, P<0.01).In addition to, in spite of the mean of Ni level (0.195±0.035) upper than Co mean level (0.158±0.115), there were a non-significant difference (P=0.175, P>0.05). And Cr (Co/Cr) alloys mean level (0.058±0.029), while from (Ni/Cr) was Zero.

Table 4: Mean comparison of Ion releasing (Co/Cr) & (Ni/Cr) after immersion 60 days in artificial saliva (A.S) at PH = 2.3.

Ion releasing after immersion 60 days in A.S. PH = 2.3		N	Mean ppm	Std. Deviation	t-test (P-value)
CO	Co (Co/Cr)	20	0.158	0.115	P=0.175 Non
& Ni	Ni (Ni/Cr)	20	0.195	0.035	sign. (P>0.05)
Cr	Co/Cr	20	0.058	0.029	P=0.00 Highly
	Ni/Cr	20	0	0	sign. (P<0.01)
MO	Co/Cr	20	0.082	0.029	P=0.00 Highly
	Ni/Cr	20	0.148	0.062	sign. (P<0.01)

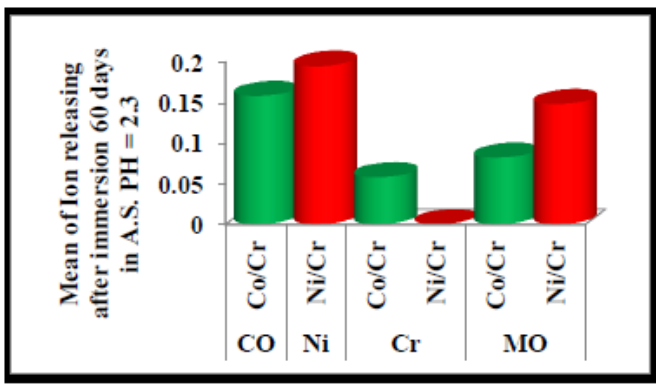

Figure 5: Mean comparison of Ion releasing (Co/Cr) & (Ni/Cr) after immersion 60 days in artificial saliva (A.S) at PH = 2.3.

Non-significant difference (P=0.354, P>0.05), when compared between mean of total Ions released from (Co/Cr) alloys (0.099±0.082) level & (Ni/Cr) alloys faintly enlarged level (0.114±0.093) immersions 60 days in artificial saliva (A.S) at PH = 2.3, (table 5) & (figure 6).

Table 5: Mean comparison of total Ions releasing (Co/Cr) & (Ni/Cr) after immersion 60 days in artificial saliva (A.S) at PH = 2.3.

Total Ions releasing after immersion 60 days in A.S. PH = 2.3	N	Mean ppm	Std. Deviation	t-test (P-value)
(Co/Cr)	60	0.099	0.082	P=0.354
(Ni/Cr)	60	0.114	0.093	Non sign.
Total	120			(P>0.05)

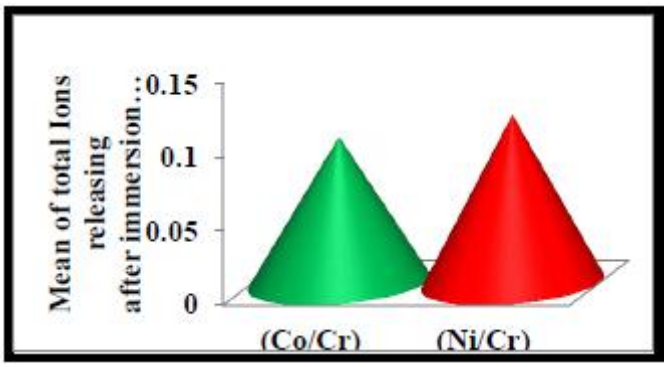

Figure 6: Mean comparison of total Ions releasing (Co/Cr) & (Ni/Cr) after immersion 60 days in artificial saliva (A.S) at PH = 2.3.

DISCUSSION

Ion released on PH = 2.3

Data obtained from (table2) & (table 3), revealed that level of Co & Ni ions were released larger than Cr or Mo level, and Cr not released from (Ni/Cr) and Cr level lowest than other ions in (Co/Cr) alloys, these facts agree with **(Denizoğlu et al., 2004 and Metikoš-Huković et al., 2006)**,[13,14] which reported that release of Co ions was more than Cr ions, and the release of higher amount of Co ions was associated with the lower pH of the test solution. Moreover, The rate of dissolution of Ni is higher than that of Cr, MO.[15] Cr releases from (Ni/Cr) and (Co/Cr) alloys were much lower in comparison to the release of Co and Ni and Mo. Other studies have also reported similar low Cr release in different immersion solutions.[16] Cr is added to base alloys to improve their ability to form a protective oxide film on the surface.[17] In addition to, Mo release from (Ni/Cr) more than (Co /Cr) (table 4) (Figure 5), Molybdenum plays an active role in the formation of the oxide layer, and Ni more than Co

ion agree with authors noted that greater amount of element release (especially Mo, Ni) from (Ni/Cr) as compared to (Mo, Co) from (Co/Cr).this lead to (Co/Cr) showed high resistance to corrosion,[18,19] however disagree with **(Reclaru et al., 2005),**[20] provide that the corrosion resistance of the alloys was decrease when the PH of the solution was lowered to 2.5.[10] (table 5), compared between total ion release from (Co/Cr) and (Ni/Cr) alloys indicated that a non-significant which may be alloys had a high Cr content (25.7 wt. %), and high percentage of molybdenum (11 wt. %), and agree with[21] illustrated that the best corrosion resistance compared with that of Commend alloy which contain a low Cr and molybdenum content (Cr: 14 wt. %, Mo: 4.7%). Thus, chromium as chromium oxide (Cr2O3) and molybdenum as molybdenum oxide (Mo3) provide the initial stability to prevent dissolution of metal ions and thus provide resistance to corrosion. Electrochemical corrosion behavior of (Co/Cr) and (Ni/Cr) dental cast alloys depends primarily on the Cr and Mo levels in an alloy.[22,10] Many dental casting alloys which have good mechanical properties, on the other hand aren't good enough from the aspect of corrosion because of their complex structure.[8] The materials employed in the mouth must be completely tarnish-resistant, they must not react with the many alkaline and acid foods that are taken into the mouth, and they cannot be affected by mouth fluids.[23] In most alloy- electrolyte systems, corrosion stops on the more surface by creation of a surface oxide layer which is good protection from further corrosion.[24]

Ion released in PH= 6.5 and PH= 7.3:

It was obvious from the results ions released at PH (6.5 &7.3) didn't release anything from (Co/Cr) & (Ni/Cr); this may be due to the formation of a protective passive layer (oxide). The stronger passive layer, the better corrosion resistance of a dental alloy; these fact agree **with (Gil et al., 1999[25] and Li et al., 2014)**[26] which noted, passive film becomes more stable as pH values increasing. While disagree with **(Trépanier and Pelton, 2006)**,[27] documented that emphasized re-passivation of material at Increase in the pH did not affect the corrosion resistance of the material.

CONCLUSION

On the base of the results obtained in this study, the following conclusions can be drawn:

1- Only acidic medium PH= 2.3 ions released from both metal alloys.
2- Cr ion was small amount released in artificial saliva from (Co/Cr) while zero released from (Ni/Cr) alloys.
3- The major amount ions released within first 30 days.

4- Mo released from (Ni/Cr) alloys more than (Co/Cr) alloys.
5- Total ion release from (Co/Cr) and (Ni/Cr) alloys indicated that same level.

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